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SYNTHESIS OF LINK MECHANISM IN VERTICAL CAROUSEL MACHINE

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ABSTRACT
This paper presents kinematic synthesis of linkage mechanism of vertical carousel machine. Basic requirement of the mechanism is, trays in machine should not get reversed. The mechanism is developed graphically to trace each point representing co-ordinates of roller which always keeps tray horizontal. Modeling of the guide-way and supporting frame is done on CATIA V5 software. It is then imported in ADAMS VIEW software and simulated. Joints between links and pins, rollers and pins, chain links and pins are revolute joints. Suitable angular velocity to perform simulation is considered. These simulations were performed with different time steps and durations. As a result of this work, displacement, velocity and acceleration at each instance and angle for rollers, pins and links are observed.

KEYWORDS*: ADAMS VIEW, Vertical Carousel Machine, CATIA V5, Kinematics, Graphical method.*

INTRODUCTION
Industrial carousel is a type of “moving shelving unit” that brings a stored item to the order selector. The product stored on a carousel may be a retail product, shortest routing principle to deliver the requested items at an ergonomic height to the operator. Assad Anis used ADAMS software to analyze manufacturing part, or a customer order.A vertical carousel consists of trays that travel vertical in front of an access window; one or several chains drive the tray, which are arranged according to the nature, dimensions and weight of items to be stored. This type of storage is generally associated with stock management. It also consists of a control and management panel. Carriers (shelves) are connected to transport chains that rotate the entire stored inventory around inside a steel clad casing in either direction working on the slider-crank mechanism [1]. Mohammad Rajbarkohan used ADAMS and Newton’s laws of motion to investigate the effect of engine RPM on crankshaft and connecting rod [2].

However no work is performed regarding kinematic analysis of vertical carousel mechanism. The kinematic analysis also can be used further for kinetic analysis. In order to do the kinematic analysis, this paper presents a combination of CAD (Computer Aided Design) software, MBD (multi-body dynamics) software and graphical method is used [3].

SYSTEM UNDER INVESTIGATION
The 3D view of the mechanism to be investigated is shown in figure 1. As the figure indicates, the system is assembly of many components.

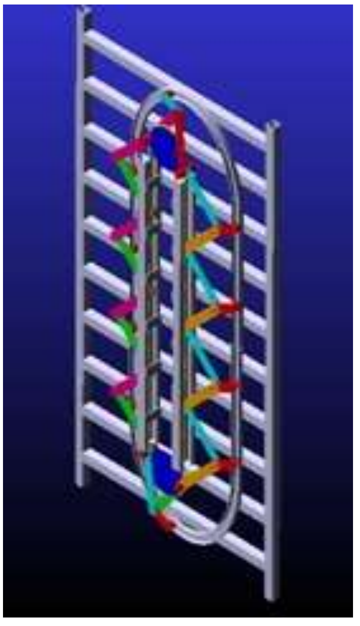

Fig. Half part of carousel machine mechanism

The description of components is expressed in table I, II, III and IV.

TABLE I Description of links

Body	Length mm	Width mm	Depth mm	Moment of inertia mm^4	Mass N	Quantity
Main link	300	50	5	135	6.5	20
Guide link	100	50	5	52.75	2.65	10

TABLE II Description of roller and pin

Body	Length mm	Radius mm	Quantity
Roller	25	20	30
Outer Pin	50	2.5	10
Inner pin	80	2.5	20

TABLE III Description of guide-way

C channel	Length mm	Inner width mm	Outer width mm	Thickness mm	Quantity
Inner	1550	40	50	5	4
Outer	1427	40	50	5	2

TABLE IV Description of elliptical guide-way

Half major axis mm	Half minor axis mm	Inner width mm	Outer width mm	Thickness Mm
295	245	40	50	5

TABLE V A) Description of uniform chain

Chain pitch mm	Chain width mm	Pitch to back mm	Roller diameter Mm
10	10	3.4	6.5

TABLE V B) Description of sprocket

Type of sprocket	Sprocket width Mm	No. of teeth	Pitch diameter
Roller	8	78	266

FORCE ANALYSIS

Parameters that affect force in links are included angle between main links, length of main link and chain pitch. We have assumed length of main link as 300mm. From geometry of the linkage mechanism it is clear that angle between main links should be 90°. But for 300mm long link, included angle covers 42.4 links (approximated to 42 links). Hence included angle is also adjusted to 88.83°

Initial tension in the chain mounted on sprockets obtained in ADAMS VIEW Machinery is -56.11N

GRAPHICAL SYNTHESIS

Outer guide-way must be designed in such a way that, trays will not be reversed.

Included distance between two main links is 420mm. To trace the position of outer roller, first position of cross-section of two main links is found out. For the links mounted on chain, in contact with sprocket, linear distance s converted to angular distance. These distances are marked on chain and cross-section points of main links are found out. These points are shown in fig. by small letters.

Further, position of outer roller is marked at angle 30° and guide link length 100mm.

This plot was traced for upper sprocket. For lower sprocket same procedure should be followed but angle of guide link to horizontal plane should remain in first quadrant.

Stepwise process of graphical synthesis is given below

1. Draw circle having diameter equal to PCD of sprocket.
2. Draw vertical tangents to the circle.
3. Mark distance 420mm from tangent point on the tangent.
4. Convert linear distances to angular distances.
5. Mark angles 10º, 20º, 30º up to 180º on circle.
6. Mark distances converted from angles on tangents.
7. Take 300mm measure in compass and bisect 420mm distance from each angle.
8. Mark these points with capital letters A, B, C, up to K. These points are joints between main links and connecting link.
9. Follow same procedure for lower part of the outer guide-way.

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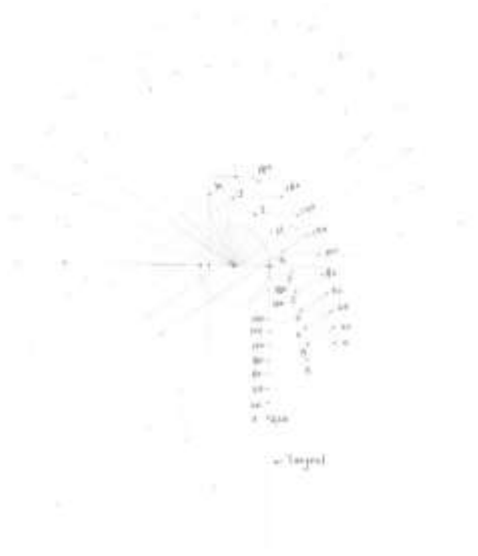

Fig. Graphical synthesis

Farthest co-ordinates denote distance of major axis and minor axis.

CAD MODEL

Guide-way and frame assembly are welded together. CAD model is created using the co-ordinates on CATIA V5 software.

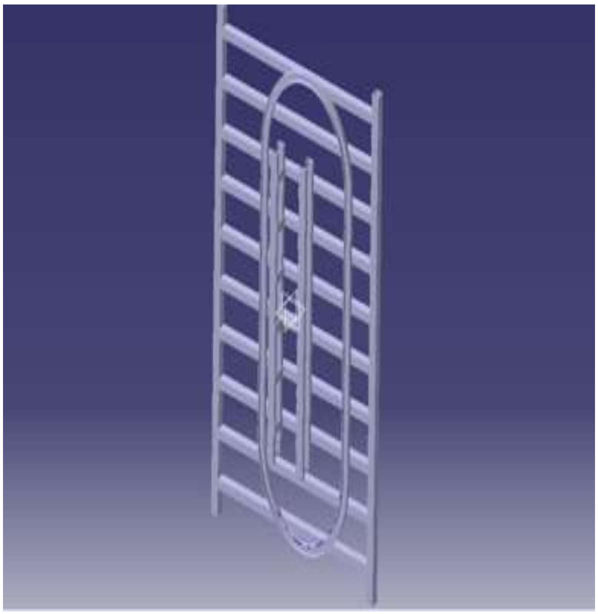

Fig. CAD model created in CATIA V5

IMPORTING CAD MODEL to ADAMS VIEW

The CAD model file in CATIA V5 is saved with extension '.CATPart'. This file is imported in ADAMS VIEW from the proper location.

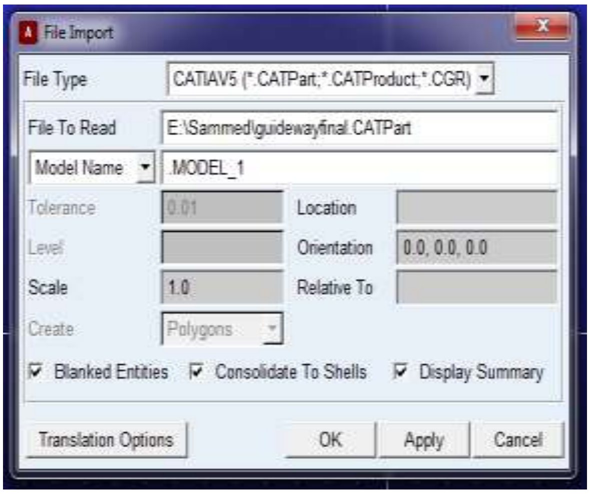

Fig. Indicating file import from CATIA V5 to ADAMS VIEW

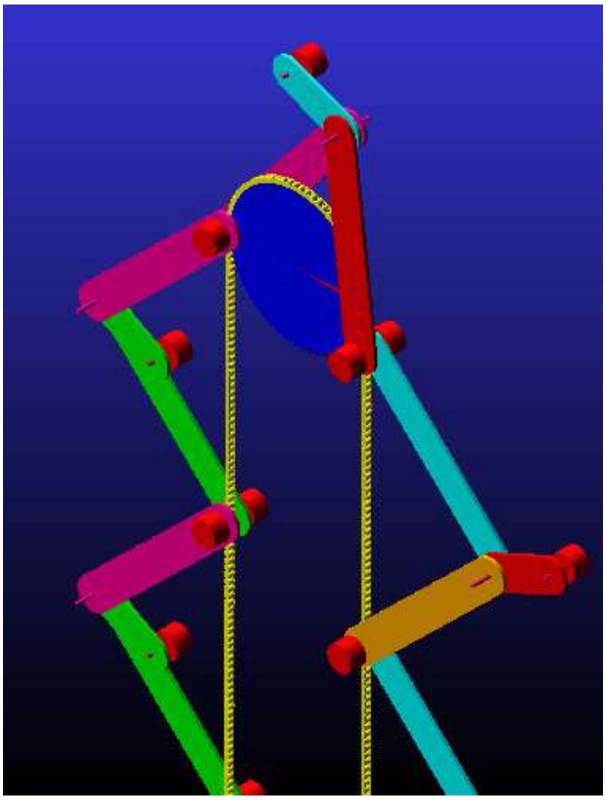

Fig. 3D model indicating assembly of main links, guide links, sprocket, chain, rollers and pins. (Guide way frame hidden).

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A. RIGID BODIES

The mechanism has the following bodies:

- Main link
- Guide link
- Guide-way frame
- Roller
- Outer pin
- Inner pin

B. DESCRIPTION OF JOINTS

Inner pin is inserted in roller of chain link with revolute joint. Main link and inner pin is connected with revolute joint. Inner pin at cross section of main link is connected to both main links with revolute joint. This pin is again connected to guide link with revolute joint. Two rollers at each inner pin and one roller at each outer pin are connected with revolute joints. Contact forces are applied at each roller with respective guide-ways. Fixed Joint is applied between guide-way frame and ground.

Table VII Description Of Joints, Contacts And Motion.

Joints	Revolute Joint	Fixed Joint	Contact forces	Motion
Quantity	102	1	30	1

STATIC EQULIBRIUM

After modeling and defining constraints, static equilibrium has been determined successfully by running simulation with end time 0.25 seconds and step size 0.01 Fig. In static equilibrium, all the reaction forces in body are zero.

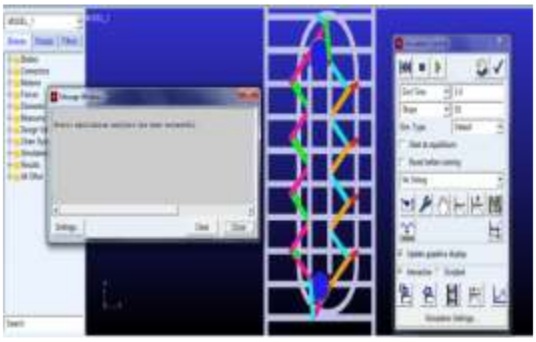

Fig. Static equilibrium of the system

APPLYING MOTION

Lower sprocket is used to drive this mechanism and hence rotational motion is then applied at revolute joint of the lower sprocket B with 30rad/sec

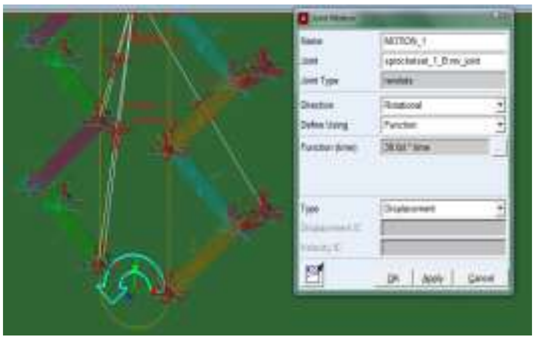

Fig. Application of rotational motion on lower sprocket.

For finding the response of the objects, simulation is run for 15 seconds duration and time step of 0.001. The model has been verified successfully with no redundant constraint.

Table VII Number Of Parts, Joints , Forces And Dof

Moving Parts	Revolute joint	Motion	DOF
513	102	1	2564

From the post processor of ADAMS VIEW, plots of displacement, velocity and acceleration for each part in assembly can be obtained.

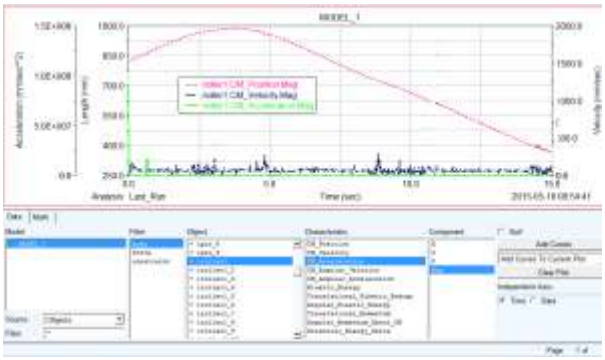

Fig. Displacement, Velocity and Acceleration response of outer roller.

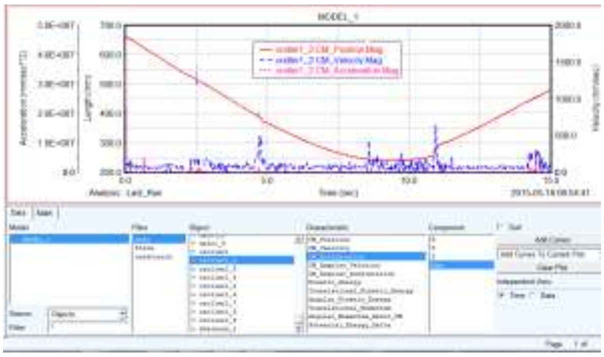

Fig. Displacement, Velocity and Acceleration response of inner roller.

The numerical values obtained from the plots for displacement, velocity and acceleration for outer roller and inner roller are shown in following table.
All values are magnitudes values of X, Y, Z, directions for respective parts.

TABLE VIII Displacement Magnitudes

Part name	0 sec	5 sec	10 sec	15 sec
Outer roller	660mm	370mm	240mm	475mm
Inner roller	830mm	975mm	625mm	375mm

Likewise tables for linear velocities and accelerations can be obtained. Local maxima and minima also can be obtained. These plots can also be useful to find causes of interrupted results.

DISCUSSIONS

The mechanism consists of 513 moving parts. Therefore the generalized coordinates needed to express the system are

6 (513) = 3078---------------------------------------1

The Jacobin matrix needed to express the system will be of 3078x2564 order as there are 2565 constraint equations needed to express the system (i.e. the system has 2564 DOF and dynamically driven). But in case of rotational motion the system has 2064 DOF because of the motion acts as the constraint and therefore dynamically driven.
Static equilibrium has been achieved with end time 0.25 seconds and step size 0.01 in ADAMS software.

CONCLUSIONS

Vertical carousel machine mechanism has been analyzed using ADAMS VIEW software. Responses of the parts at each instant have been plotted by giving rotational motion of 30 rad/sec to lower sprocket. All the models have been verified successfully. Further simulations are recommended to find out contact forces at each roller, joint reactions. Simulations with addition of friction in analysis of vertical carousel mechanism are also recommended.

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